OFFICE OF HIGH ENERGY & NUCLEAR PHYSICS

REMARKS AT SLAC USERS GROUP MEETING

July 7, 2000

S. PETER ROSEN
ASSOCIATE DIRECTOR
FOR HIGH ENERGY & NUCLEAR PHYSICS

WHY SUPPORT

HIGH ENERGY & NUCLEAR PHYSICS

?

(1) The science of matter and energy at the deepest and most fundamental level.

(2) Over the past 50 years, both fields have been extremely successful: scientifically, technologically, and sociologically.

(3) Both fields have strong impact on other fields of science.

(4) Both fields are poised to make major discoveries over the next decade.

(5) The need to plan for the decades beyond.

OFFICE OF HIGH ENERGY & NUCLEAR PHYSICS

(1) The science of matter and energy at the deepest and most fundamental level.

- **Continuation of an age-old quest to understand the world around us going back to ancient Greece and even earlier.**

- **At the intellectual and technological cutting edge, responding to new challenges and developing new knowledge which helps to extend science on a broad front.**

(2) Over the past 50 years, both fields have been extremely successful:

Scientifically

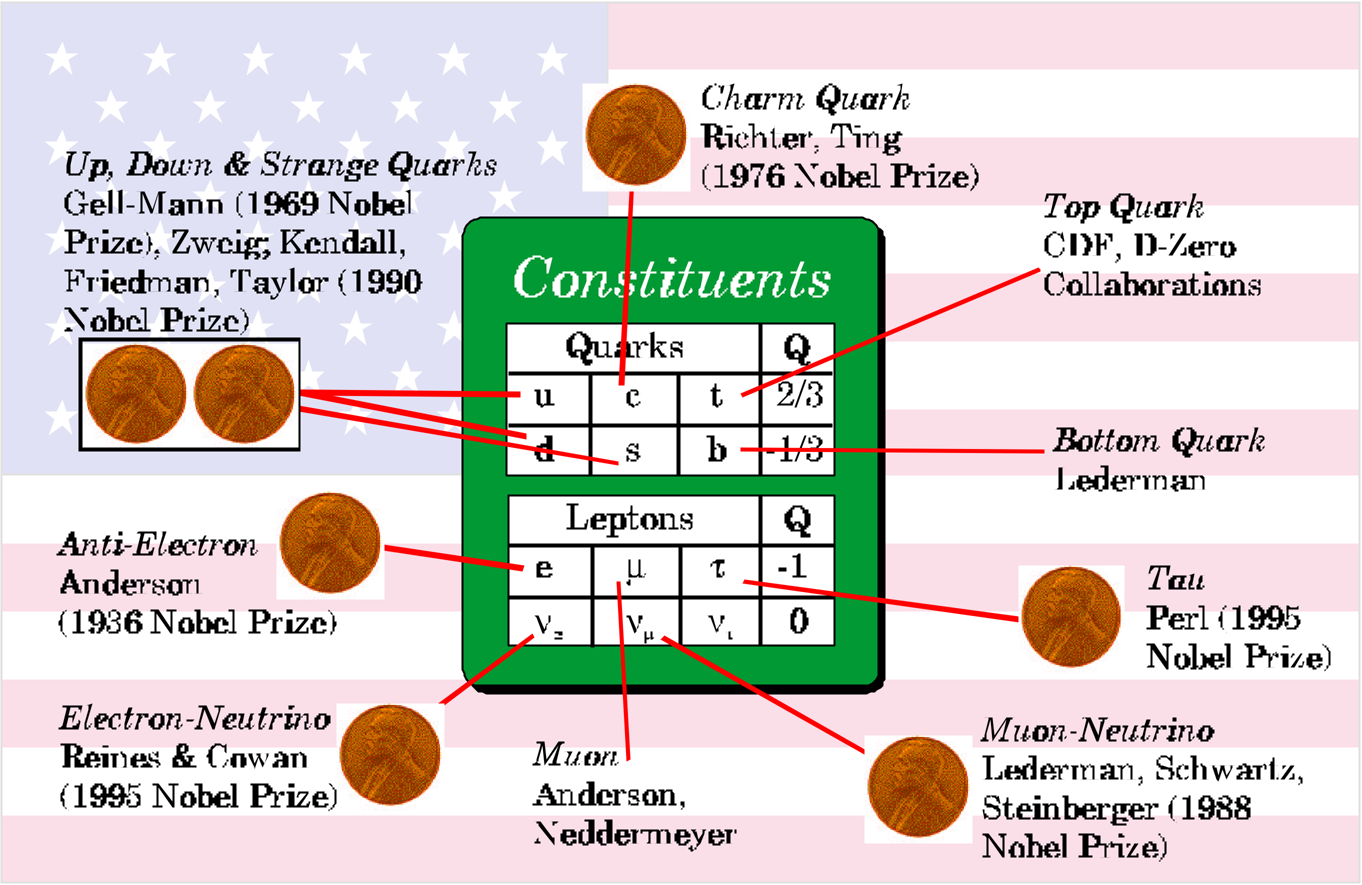
Technologically

Sociologically

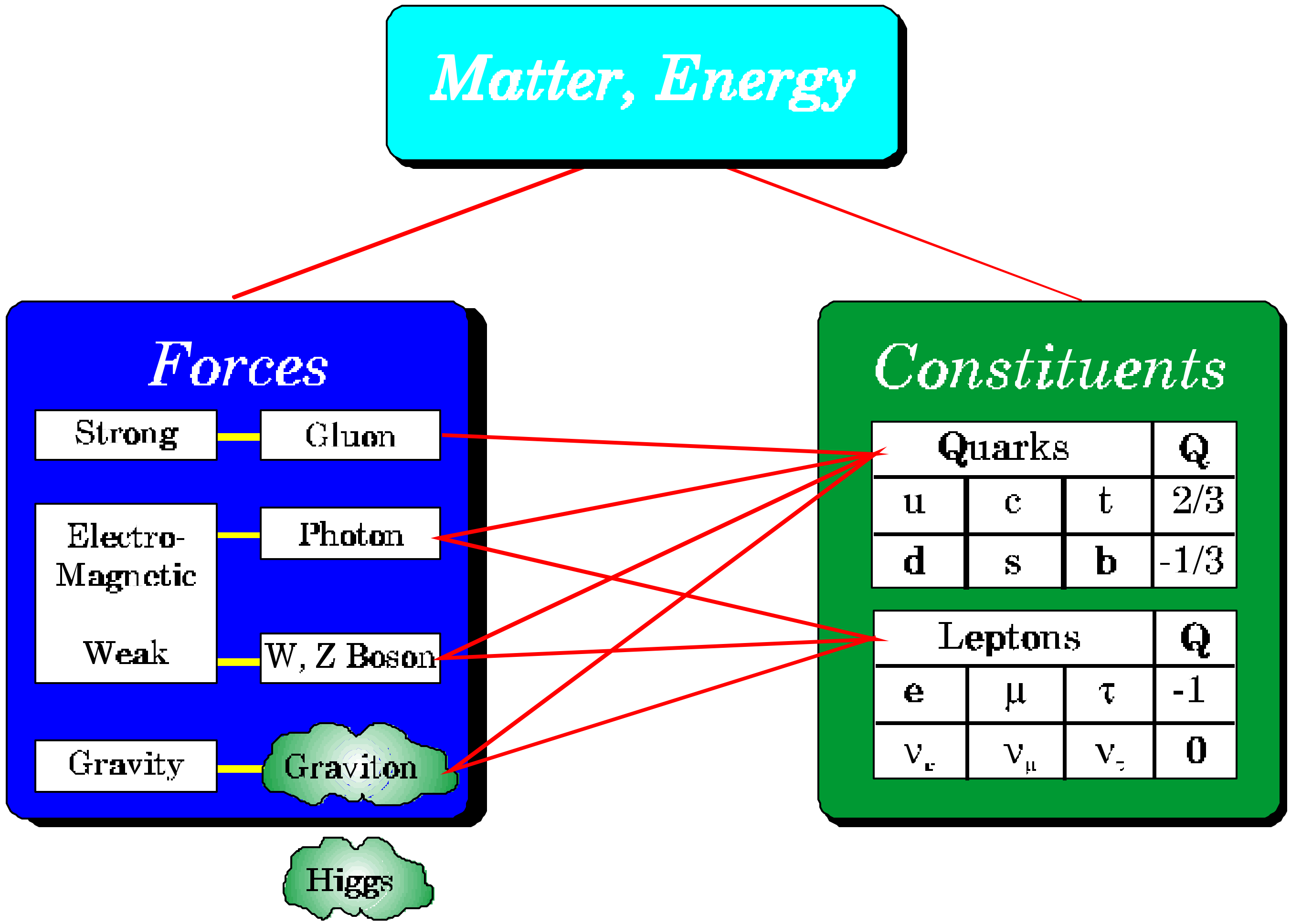
(i) Scientifically

- **Discovery of quarks, a deeper level in the fundamental structure of matter;**
- **Discovery of W, Z, and gluons, the carriers of fundamental forces;**
- **Development of the standard model, amazingly successful even though it leaves many questions unanswered.**

U.S. High Energy Physics Program's Contributions to the Standard Model



The Standard Model



(ii) Technologically

- **Accelerators from E.O. Lawrence's hand-held cyclotron (circa 1937) to today's B-factories, Tevatron, and LEP to tomorrow's LHC;**

- **Detectors from the cloud chamber to the bubble chamber to today's electronic monster-marvels at SLAC, KEK, Fermilab, RHIC and CERN;**

(ii) Technologically (cont'd)

- Underground laboratories from Ray Davis' solar neutrino detector at Homestake (circa 1967) to IMB's water Cerenkov detector (~1980) to Gran Sasso, SuperKamiokande (one of the wonders of the world) and SNO;

- Computing, from Monte Carlo to DAQ to handling of large data sets to World Wide Web.

Computing is Essential to High Energy Physics

- **Massive increases in data (petabytes/year): CDF D0 ATLAS CMS**
- **Advanced computational and data management facilities for HEP.**
- **Network connections to facilitate worldwide collaboration.**
- **New tools for science:**
  lattice QCD accelerator simulations supernova simulation
- **Scientific Discovery through Advanced Computing (SDAC)**
  (a DOE multiprogram initiative)

(iii) Sociologically

- **From individual scientist at home institution benchtop to large multi-hundred collaborations working at major external facilities;**
- **International collaborations, foreign scientists working on specific experiments, detectors at U.S. facilities, and U.S. scientists working abroad;**
- **Trans-oceanic communications and networking; the World Wide Web.**

(3) Both fields have strong impact on other fields of science:

for example,

- **Intellectual ties with cosmology and astrophysics; the role of quarks and gluons, elementary particles and nuclei in the evolution of the universe from the Big Bang to the present day; Steve Weinberg's comment in "Time" of 10 April 2000 that a major impact of a "Theory of Everything" would be on cosmology and the origins of the Universe;**

- **Interaction with computer science in the management and mining of superlarge data sets.**

(3) Both fields have strong impact on other fields of science:

for example, (Cont'd)

- **Applications of accelerators to light sources, neutron sources for material sciences, chemistry, structural biology, environmental science; also to medicine and industry, e.g., proton therapy and ion implantation;**
- **Sociologically, knowledge and problem-solving skills, teamwork and communications, people sought after by industry;**
- **Ability to deal with challenge of doing things that have never been done before.**

Connections

With other fields of science:	Cosmology, astrophysics, accelerators in biology and materials science
With other countries:	Europe, Russia, Japan, China, . . .
With other agencies:	With NSF in NSAC and HEPAP, in specific projects like LHC
	With NASA in specific projects such as AMS, GLAST, Booster Applications Facility at Brookhaven, Astrophysics Group at Fermilab

International Connections

- Fermilab 1999: 885 visitors from other countries, 775 from the U.S.
- LHC is a major part of the U.S. high energy physics program.
- Over half the physics majors at U.S. universities are from other countries.
- 36% of science Ph.D.'s in U.S. are earned by students from other countries.
- Future major facilities for high energy physics will have to be international.

(4) Both fields are poised to make major discoveries over the next decade:

- **There are strong indications from current experiments at LEP and Fermilab and SLAC that there might be a light standard model or supersymmetric Higgs; could be found at LEP, or Fermilab, or most likely at LHC.**
- **Possibility of finding light Susy particle Fermilab, and/or LHC.**
- **Neutrino masses and mixing from non-accelerator experiments, SuperK, SNO, Borexino, Kamland, and from long-baseline accelerator experiments, K2K, NuMI/MINOS, CNGS.**
- **CP violation from B-Factories, Fermilab.**
- **Possibility of discovering the quark-gluon plasma at RHIC.**
- **"Other" exciting developments not foreseen today.**

Particle Astrophysics

Cosmic rays

AMS (search for antimatter and nature of cosmic rays)

Pierre Auger (search for events > 10^{19} eV)

GLAST (measure gamma rays 20 MeV – 300 GeV)

Dark matter

CDMS II (Cryogenic techniques. Has become topical because of claims by DAMA in Italy to have seen WIMPs.)

Survey of northern sky

SDSS (measuring the most distant quasars)

Dark energy (accelerating universe)

SNAP (space-based large aperture telescope to observe and measure 2000 supernovae in one year)

(5) The need to plan for the decades beyond:

- **What are likely to be the driving questions for high energy physics in the next 25 years?**
- **What are the tools, accelerator and non-accelerator, that will be needed to try to answer those questions?**
- **What are the goals of the U.S. HEP community and how will it achieve them?**
- **What are the goals of the international HEP community and how will it achieve them?**

- **The Gilman Subpanel recommended:**
  - **“. . . that a new facility at the energy frontier be an integral part of the long-term national high-energy physics program.”**
  - **“. . . that SLAC continue R&D with Japan’s KEK toward a common design for an electron-positron linear collider with a luminosity of at least $10^{34}cm^{-2}s^{-1}$ and an initial capability of 1 TeV in the center of mass, extendible to 1.5 TeV. . . [and] that SLAC be authorized to produce a Conceptual Design Report for this machine in close collaboration with KEK.”**
  - **“. . . that an expanded program of R&D be carried out on a muon collider, involving both simulation and experiments.”**
  - **“. . . an expanded program of R&D on cost reduction strategies, enabling technologies, and accelerator physics issues for a VLHC . . . [and] efforts should be coordinated across laboratory and university groups with the aim of identifying design concepts for an economically and technically viable facility.”**

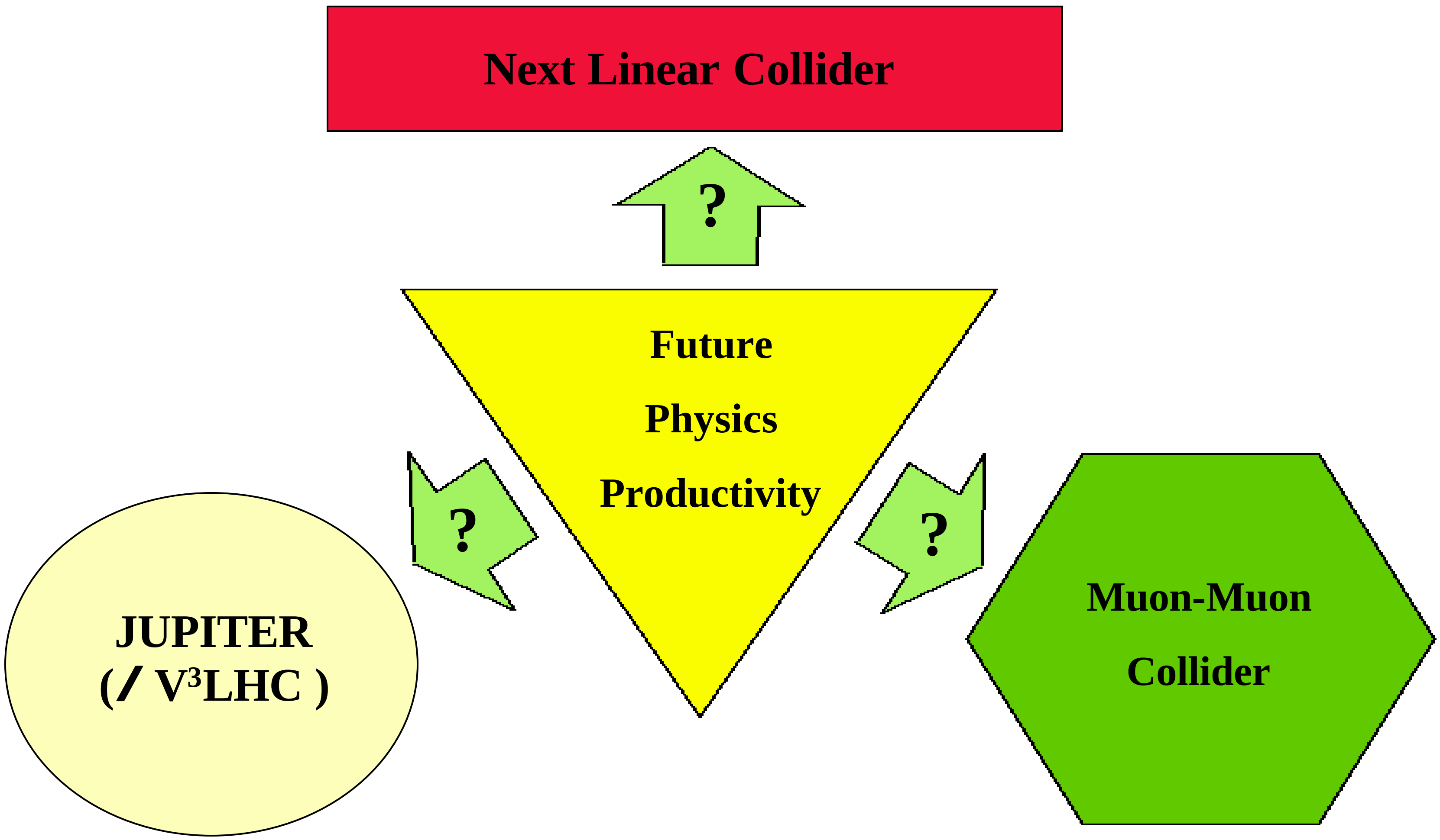
OFFICE OF HIGH ENERGY & NUCLEAR PHYSICS

Need to sharpen the focus of the Gilman Subpanel recommendations:

- **Which were based upon a flat (only cost of living) budget or better, whereas we have a essentially a flat-flat budget (equal $, no c.o.l.).**
- **Utilization of new and forthcoming facilities; important for physics and for our credibility with executive and legislative branches.**
- **LHC, which is proceeding well, with established mgmt structure in place**
- **Restore and strengthen university program, including R&D for future accelerators (See Al Tollestrup, Fermi News 2/19/99, p.5)**
- **Sacrifice of good physics because of new opportunities and budgetary constraints (e.g. SLC/SLD program and AGS HEP program).**

SHOULD WE BEGIN TO PRIORITIZE OUR OPTIONS FOR A FUTURE FACILITY BEYOND LHC?

The Snowmass `96 Legacy



Need to make the case for a future HEP facility to decision makers BEYOND HEP community:

- **Requires support from the total HEP community.**
- **Complementarity of hadron and lepton accelerators.**
- **The scientific case needs to be spelled out in convincing detail.**
- **Importance to U.S. of maintaining world leadership in fundamental science.**
- **Strong intellectual connections with other fields, especially cosmology and astrophysics, nuclear physics; (but also condensed matter).**
- **Advancing HEP advances all of science through applications of new HEP technology; (accelerators, detectors, computational & data management).**
- **The challenge of doing things that have never been done before.**

WE MUST REACH OUT TO COLLEAGUES IN OTHER FIELDS

University Program is Crucial for Success

- The total DOE budget for high energy and nuclear physics exceeds $1 billion, approximately $700 M for high energy physics and $350 M for nuclear physics. This supports research at national laboratories and universities.
- DOE spends approximately $115 M on research in high energy physics at 103 universities. This supports the work of 600 faculty members, 400 postdocs, and 500 graduate students.
- DOE spends approximately $63 M on research in nuclear physics at 87 universities. This supports the work of 360 faculty members, 230 postdocs, and 340 graduate students.
- Four new facilities in high energy and nuclear physics:
  - Main Injector, B-Factory, RHIC, CEBAF. 6000 users, mainly from universities in this country and abroad.

University Program (continued)

- In addition to experiments at accelerators, DOE supports non-accelerator experiments in this country and abroad, for example, CDMS II at the Soudan Mine in Minnesota, SNO in Canada, SuperKamiokande in Japan, SAGE in Russia, MACRO and other experiments in Gran Sasso in Italy.
- Universities lead our research programs.
- Universities train new scientists--for pure research and industry.
- Universities educate citizens (2/3 of all Americans go to college) for life in a complex technical world.
- Universities maintain the reservoir of human knowledge - our most valuable asset.
- Universities enable new technologies that have brought about unprecedented prosperity. They exemplify the international connections needed for a global economy.

Planning for Decades Beyond

The world HEP scientific community needs to move to the next level technologically and sociologically in order to pursue its scientific goals:

Sociological

- **The scientific field excels at working together in international collaborations on specific projects, e.g., BaBar and Belle, CDF, SuperK, Phenix;**
- **Needs to learn to plan as a single worldwide community, because of cost and skills required for major new facilities;**
- **Needs to develop international mechanisms for reviewing new proposals and choosing between competing proposals and technologies.**

Need to internationalize efforts for a future facility after LHC:

- Bringing the international HEP community together; what mechanisms do we have and do we need to develop a coherent approach?
- Bringing the appropriate government agencies from different countries together through the Global Science Forum and higher level meetings. Can we achieve this?
- Creation of an international institution analogous to CERN? Or some other model?

More good ideas than money

Requires long range planning:

HEPAP white paper this fall

Subpanel next year

Snowmass next summer

Requires interagency and international coordination:

DOE/NSF sponsorship of HEPAP

DOE/NASA cooperation on projects

Global Science Forum: formed Working Group on High Energy Physics

How Does This Relate to Government Officials?

Government officials need to:

- **Encourage the worldwide HEP scientific community in its planning, and facilitate this process where necessary or desirable;**
- **Be ready to receive proposals from the worldwide HEP scientific community and develop mechanisms for reviewing them, arriving at a consensus, and implementing those judged to be worthy and essential for further progress of the field.**

WHY SUPPORT HIGH ENERGY & NUCLEAR PHYSICS?

(6) Conclusion:

As the science of the fundamental constituents of matter and the forces between them, High Energy and Nuclear Physics have been extremely successful intellectually, technologically, and sociologically. Not only has it advanced its own scientific goals, but through its technology and sociology, it has helped much of other science to advance on a broad front. In order to continue in this valuable and positive direction, HEP scientists in particular need to plan and act as a single worldwide community, and governments need to develop worldwide mechanisms for supporting them and providing the necessary resources.

I am an optimist about the future.

OFFICE OF HIGH ENERGY & NUCLEAR PHYSICS

Keep It Up